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Agro-environmental sustainability of the Yuanyang rice terraces of Yunnan (China): lessons for Europe.

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Abstract

The Hani minority people of Yunnan Province (south-west China) have developed a complex and sustainable agro-environmental system of terraced rice paddy fields in Yuanyang (22°49'-23°19'N, 102°27-103°13'E). The Hani people have maintained this intricate and elaborate system for over 1500 years, with some 3,000 terraces covering about 11,000 hectares. Hence, during the Ming Dynasty (1368-1644), the Emperor awarded the Hani people the title of 'Magic Mountain Sculptors.' However, geographic isolation and proximity to the, until recently, politically-sensitive border with Vietnam, has meant the Yuanyang terraces have attracted scant scientific attention. If we can understand how this system is sustained, we can learn lessons which hopefully can be applied more generally.

The sustainability of the system seems to be the result of complex interplays between cultural, agronomic and environmental factors. These include the cultural and spiritual beliefs of the Hani people, a hydrogeological system which provides ample water resources, the maintenance of genetic diversity within the dominant rice cropping agro-ecosystem and the operation of complex fertigation practises. Distilling and understanding the 'secrets' of the Hani people and their terraces should enable broader application and dissemination of the principles of sustainability. Currently a joint Chinese-European team are working towards a greater understanding of these lessons. The research team postulate that these lessons will have some applicability for agro-environmental sustainability in Europe. Identified lessons relate to resource optimization, landscape multifunctionality and cultural attitudes.

Landuse within Yuanyang is zoned on the basis of ecological principles. Upland grassland progresses downslope into forest and then in a downslope sequence into tea plantations, bamboo woodland and rice terraces. Grasslands are used for the grazing of water buffalo, while wooded areas provide timber (deciduous, pine and bamboo) and food (mushrooms, wild vegetables and honey). The local Yunnan pine (*Pinus yunnanensis*) provides an excellent source of timber. Furthermore, the forest is very effective in conserving soil and water and releases high quality water from the upper to lower slopes. Besides providing rice, the perennially wet paddy fields provide food for domestic consumption (carp, eels, mudfish, ducks, frogs and snails) and weeds for pig-feed. Thus, there is multifunctional use of each eco-agricultural zone, which ensures optimum use of resources, effective recycling of materials and minimal waste. Often, the net waste from these subsystems is virtually zero.

The Hani people have a unique cultural system that reveres the land. The Hani religion embraces polytheism and the worship of nature. They pay particular devotion to the 'forest god,' which is perceived as the source of life-giving water. Deforestation is considered a religious violation and the Hani people actively teach their children to respect the forest. This concept significantly contributes to forest conservation and ecosystem stability. In Europe, we can learn much from these positive environmental attitudes, in terms of improving public understanding and appreciation of land

resources (land literacy) and agro-environmental education at multiple levels (school, college and university).

Keywords: cultural attitudes, Hani minority people, landscape multifunctionality, resource optimization, Yuanyang.

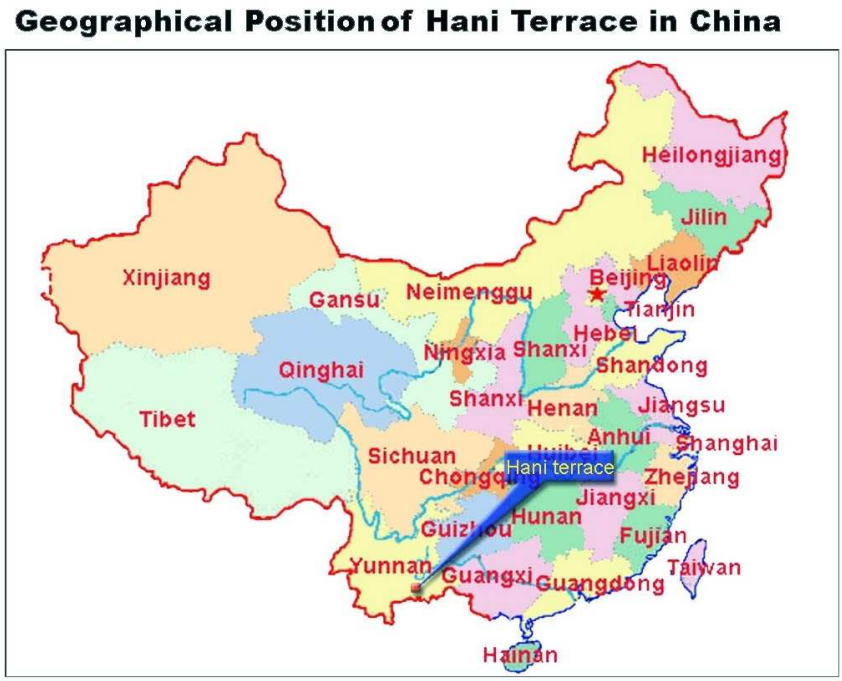

Figure 1. Location of Yunnan Province.

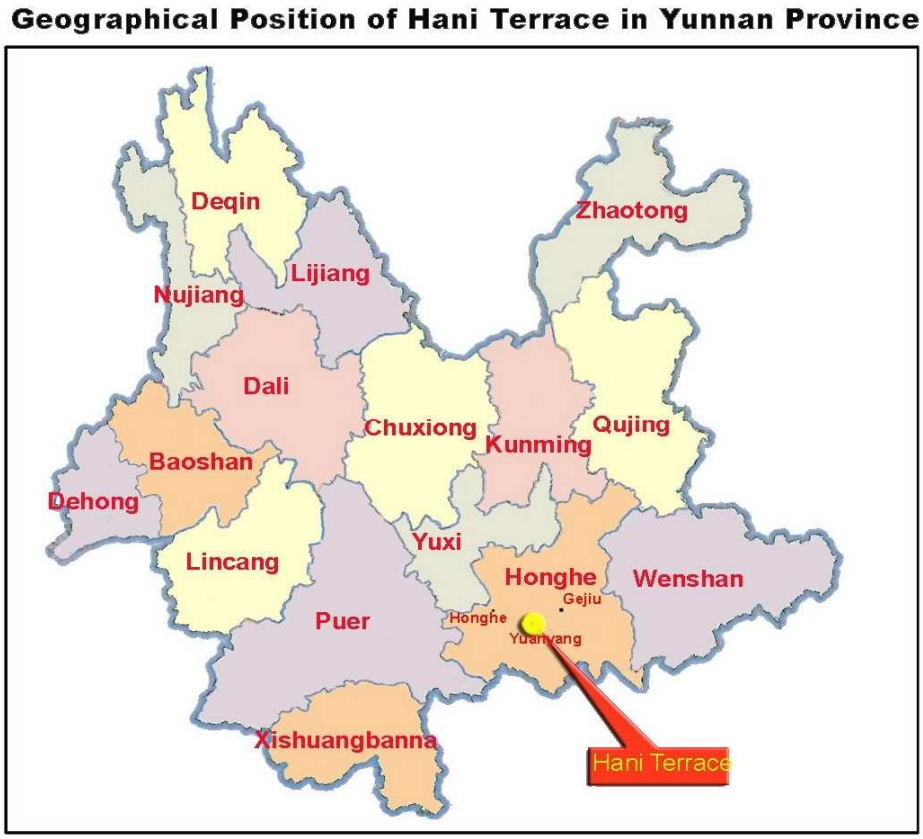

Figure 2. Location of Yuanyang within Yunnan Province.

Plates 1 and 2. Rice terraces of Yuanyang.

Introduction

The Yuanyang terraces are located at 22°49'-23°19'N, 102°27-103°13'E) (Figures 1 and 2) and are extremely spectacular (Plates 1 and 2). Thus, they have been long been a magnet for photographers and tourists, evidenced by many excellent web-based photo albums. However, the remoteness from host investigative teams (Yuanyang is 326 km south of Kunming, the capital of Yunnan Province) and the former political tensions on the nearby Chinese-Vietnamese border, has meant the area has received scant scientific study.

The 'Magic Mountain Sculptors'

The Hani minority are believed to have originated as the nomadic Qiang tribe, which migrated from the Qinghai-Tibetan Plateau to Yunnan Province in ~300 AD, where they developed their complex rice dominated terraces agricultural system (WANG 1999). During the Ming Dynasty (1368-1644), the Emperor awarded the Hani people the title of 'Magic Mountain Sculptors.' The Hani language belongs to the Tibeto-Burmese linguistic family, which adds to their distinctness from the Han Chinese majority.

The environment of the Yunnan uplands is suitable for rice cultivation with an average annual sunshine of 1,670 hours and temperature of 15.4^{o}C (WANG 1999). The area possesses considerable water resources, with ample annual precipitation. Average annual precipitation is ~1400 mm, ranging between 1200-1500 mm on lower slopes to 1500-2000 mm on upper slopes. Most precipitation falls as summer monsoon rains between May and October. The meso-scale climate effectively retains and recycles water within the Yuanyang basin, a subcatchment of the Red River basin. The valley is noted for frequent fogs. Furthermore, differential late afternoon solar heating of mountain sides induces slight pressure differences, which cause upslope (anabatic) winds to transport moist airstreams from the valley base upslope. The monsoonal precipitation falls on the Ailao Mountain Range, which rises from ~1400 m above sea-level to 2940 m.

Lithology plays an important role, with upslope rocks consisting mainly of impervious metamorphic gneiss and mica-schists, which encourage runoff into the mid-slope spring lines. Furthermore, structural geology influences hydrogeological behaviour. The main valley follows a syncline structure and so the hydrological catchment is larger than the physiographic catchment, with groundwater permeating along bedding planes into the main catchment from adjacent catchments. Furthermore, deep (~50 m) pockets of weathered material act as important water storage features and springs often originate at their bases. Thus, the mid- to lower slopes possess a multitude of springs, which are the main water source for the paddy fields.

The total Hani population is 1.44 million, of which 1.42 million live in Yunnan Province (2000 Census). About 12,500 Hani people live in Vietnam. In Yunnan, most Hani live in the Ailao Mountain Range, concentrating in southern Yunnan between the Red River (Hong He) and Mekong River. The Hani population in the seven counties of Yuanyang, Mejian, Honghe, Yuanjiang, Jinping, Luchun and Jiangcheng accounts for 76% of the total Hani population and >50% of the local population. There are two towns and 970 villages in the 2190 km^2 Yuanyang County. The total population was 371,489 (late 2004), of which the Hani minority population was 326,100 (87.8%) and the agricultural population was 351,543 (94.6%).

The seven major nationalities in Yuanyang County live at different altitudes, largely in accordance with their traditions and customs. Generally, the people living on the relatively flat valley bottoms (elevation from the lowest point of Xiaohekou village at 144 m to 600 m) are mostly Dai (Tai). At the bottom of the valley side (altitude 600-1000 m) are Zhuang people. Yi people mainly live on the lower mid-section of the valley side (altitude 1000-1400 m). The Hani people mainly live at an altitude of

1400-2000 m. Higher elevations (>2000 m) are the habitat of Miao and Yao people. Normally, the Han majority live in towns or alongside the main roads.

The Hani people have a unique cultural system that reveres the land. Even the name of their main village 'Qingkou' (Catchment Gate) is connotative of their landscape ecology. The site selection of Hani villages also indicate their environmental understanding, as Hani villages are usually located on the middle and sunny mountain slopes. At the middle part of the mountain, temperatures are mild with less possibility of disease and pest damage than at the lower warmer and more humid basal slopes and less chance of animal attack (i.e. by bears) than the higher part. Normally, a Hani village is comprised of 20-50 households and the distance between two adjacent villages is ~2 km. With such small villages and their close proximity, people can efficiently manage their lands without long walks to the fields.

The Hani religion embraces polytheism and the worship of ancestors and nature. They pay particular devotion to the 'forest god,' which is perceived as the source of life-giving water. Deforestation is considered a religious violation and the Hani people actively teach their children to respect the forest. This concept significantly contributes to forest conservation and ecosystem stability. Consequently, the existing forest area in Yuanyang County is ~28,000 ha, that is 26.7 % of land cover.

The Hani have developed complex agricultural systems. Rice is the dominant crop, but it is maintained with few additions of artificial fertilizers or pesticides. Complex fertigation systems provide most nutrients, especially nitrogen. Mixes of manure from cattle and pigs and 'night soil' are placed adjacent to channels. When needed, irrigation waters are diverted into paddy fields, inputting a nitrogen flush, especially in the early growing season. The Hani have the philosophy of dividing the rice crop into three. The upper third 'is for the people' (i.e. the crop for domestic consumption), the middle third is 'for the animals' (i.e. straw for animal consumption) and the lower third is 'for the soil' (i.e. retained as a stubble, returning nutrients to the paddy soil system and improving soil structure). Rice straw is also used for thatching the distinctive Hani 'mushroom shaped' houses.

Ancillary food production includes ducks, fish (crucian carp, *Carassius carassius*, eels and mudfish), frogs and snails. Pond weed is utilized for pig-feed. These measures provide valuable supplements to the diet and increase the nutrient loads of the perennially wet paddy fields. The nutrient budgets and aquatic ecology of this integrated water management system are under further study. In addition, bee culture provides both honey and a pollination mechanism for local crops and wild vegetables and mushrooms are harvested from the forest.

Increased crop genetic diversity can extend the cultivation period of a crop variety and the Yuanyang rice cultivars have considerable genetic diversity (ZHU YONGYONG *et al.*, 2000). Genetic diversity and careful agronomic management means rice crop yields are high, typically 4-6 t ha^{-1}, compared with the usual 2-3 t ha^{-1} in traditional cropping systems. Minimal artificial fertilizers and virtually no pesticides are used. The traditional rice varieties used by the Hani require less fertilizer inputs than modern varieties and are noted for their resistance to disease (ZHU YONGYONG *et al.*, 2000).

Land use patterns promote soil and water conservation. Hilltops are afforested, with ~15 identified species, predominantly Yunnan pine (*Pinus yunnanensis*). This land use is very effective in conserving soil and water and releases high quality water from the upper to lower slopes.

Lessons for Europe

The combination of all these identified cultural and agro-environmental factors appear to have allowed the Yuanyang rice terrace system to remain in a sustainable state. The research team postulate that these lessons will have some applicability for agro-environmental sustainability in Europe. Identified lessons relate to resource optimization, landscape multifunctionality and cultural attitudes. However, our understanding is far from complete. Thus, a joint Chinese-European team has established the 'Yuanyang Project' to explore, study and understand the factors which promote sustainability. The team is approaching these questions as inquisitive students, trying to understand the 'secrets' of the Hani people. Understanding and then presenting these findings should make a positive contribution to the broader development and dissemination of sustainable agricultural technology.

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